Deep Reinforcement Learning for optimal energy management of multi-energy Smart Grids

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Context of the problem

Figure: The Meridia Smart Energy eco-district - Energy systems

Optimization Objectives

- Reduce energy consumption, load peaks and energy bills
- Maximize self-consumption and energy self-sufficiency
- Minimize GHG emissions related to energy consumption and mobility
- Value flexibility potentials of the Smart Grid (ancillary services)

Optimization Objectives

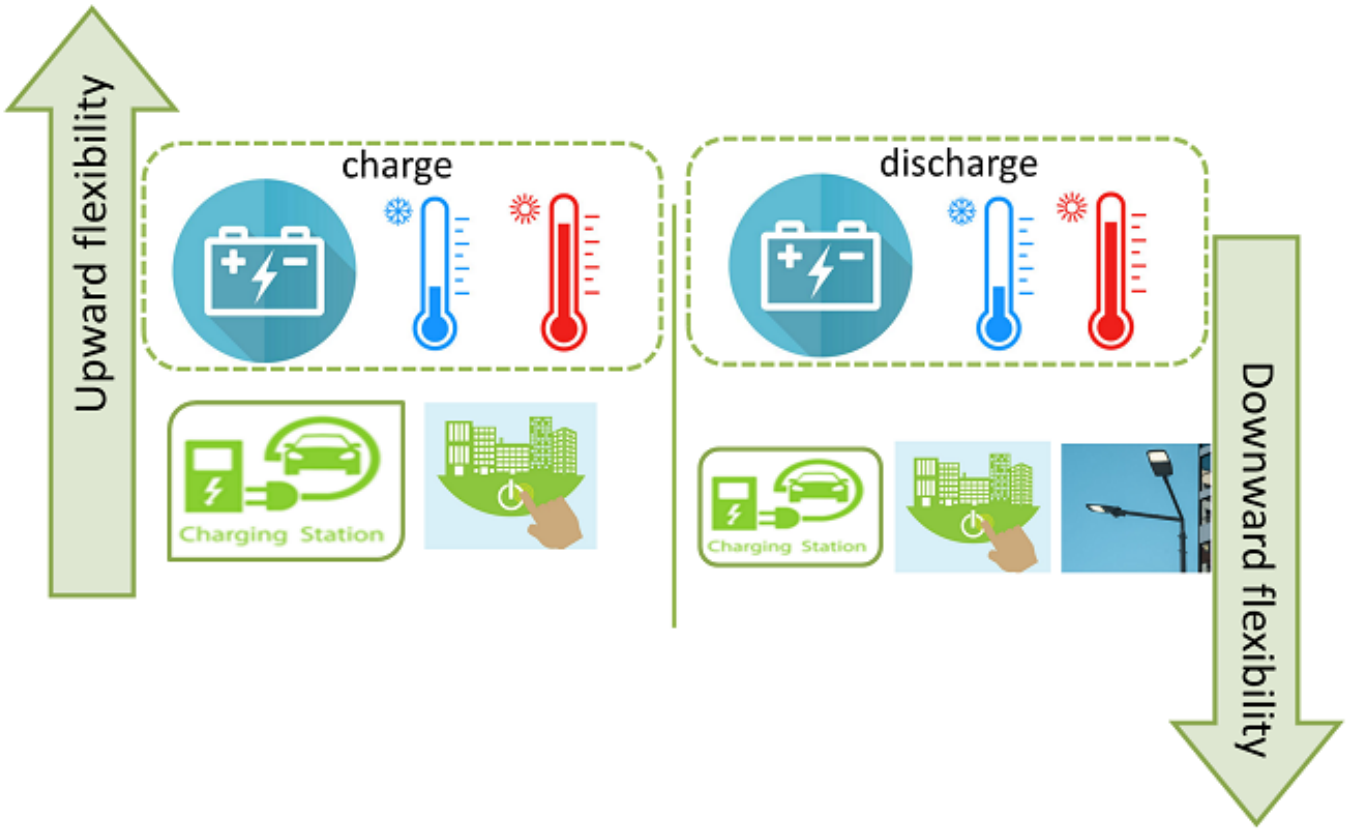

Figure: Flexibility potentials in the MSE Multi-energy Smart Grid

Optimization objectives

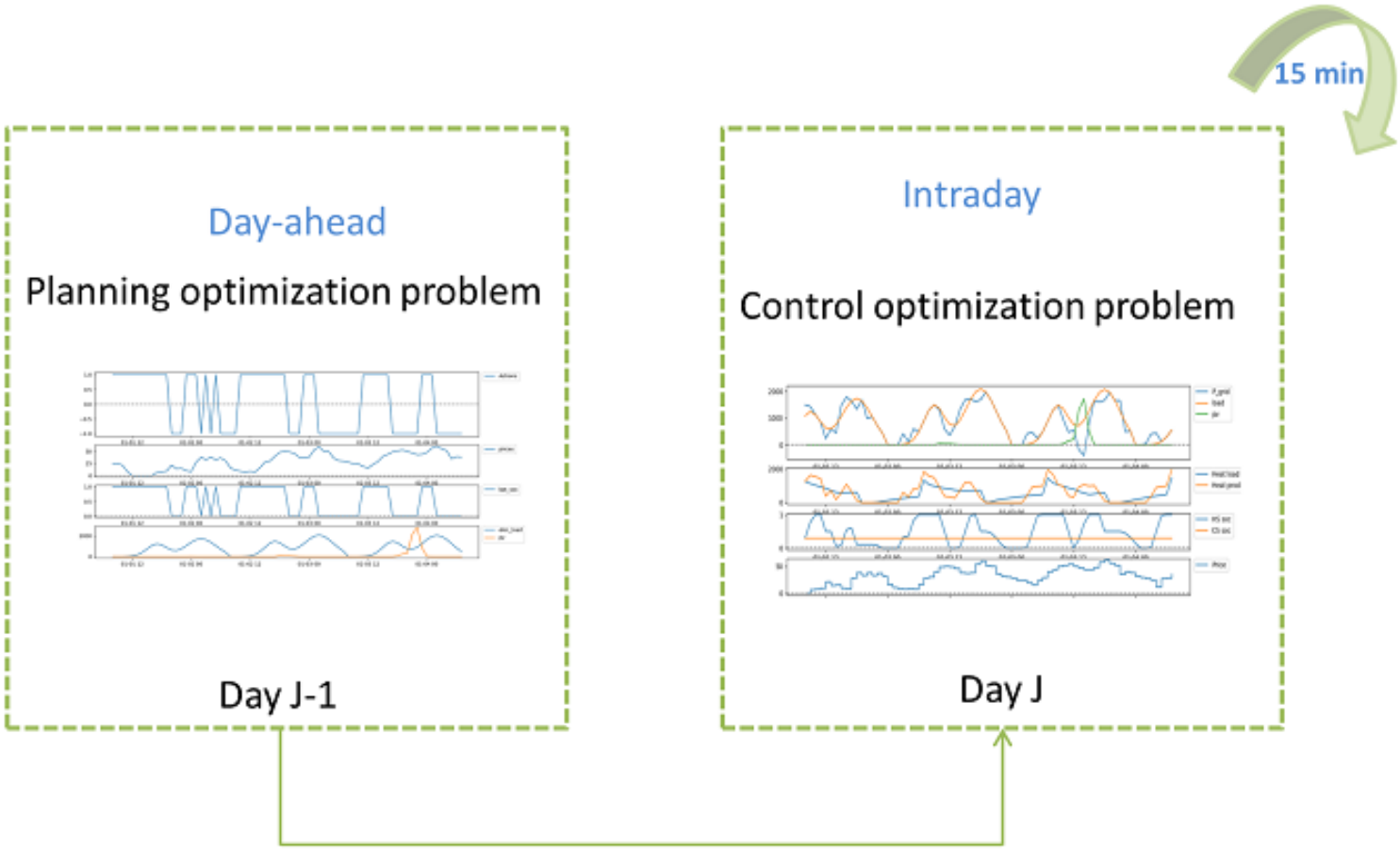

Figure: Optimal planning and optimal control of the energy systems

This work

- A wide range of methods: Exact (LP, MILP), predictive (MPC), meta-heuristics (genetic algorithms, PSO)
- Time-consuming, not suitable for on-line solutions, large-scale databases
- Rely on accurate models and predictors, appropriate solvers

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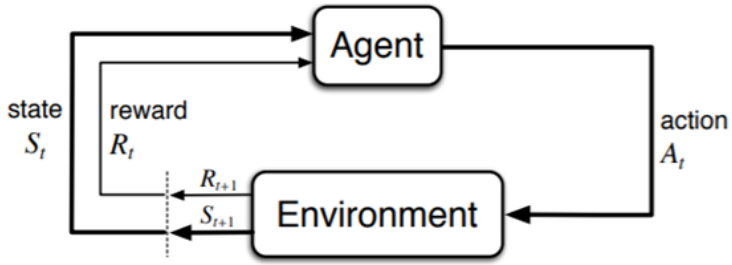
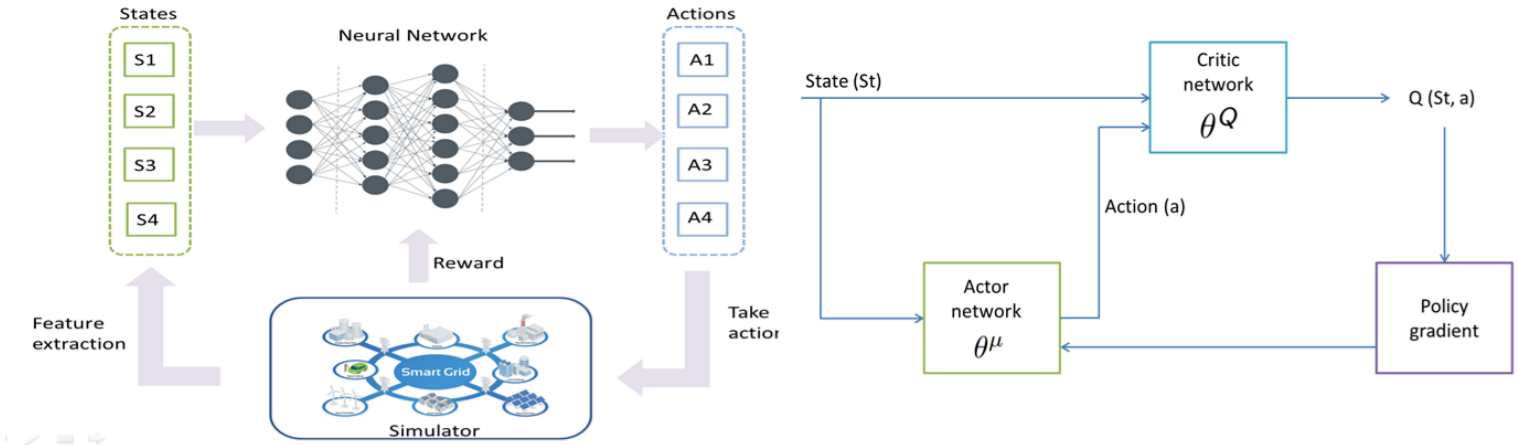


Figure: Reinforcement Learning paradigm (Sutton & Barto, 2018)

This work



- Renewable energy generation
- Buildings indoor and outdoor temperatures
- Buildings eletrical and thermal loads
- State of charge of electrical and thermal storage systems

State

- Actions on geothermal heat pumps (heat and cold production)
- Actions on PV panels (if curtailable)
- Actions on electrical and thermal storage systems (charge/ discharge)

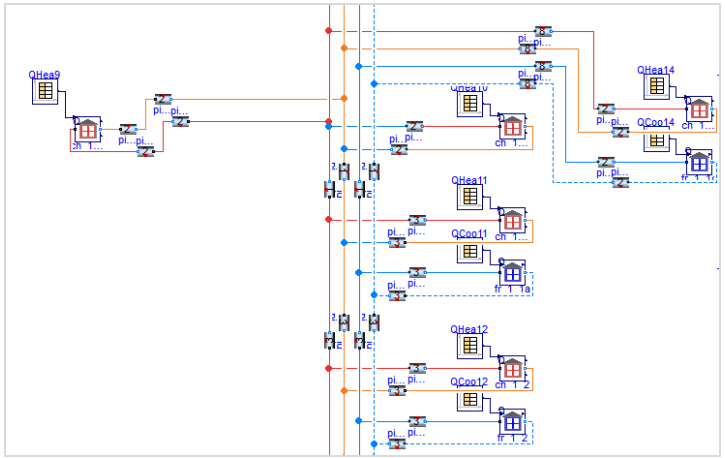
Actions

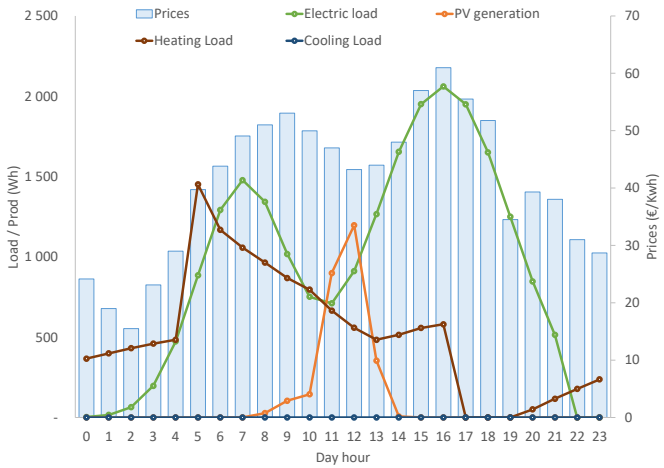
- Cost of energy consumption
- Self-consumption rate
- Income / penalties from participation in ancillary services

Reward

Figure: Deep Deterministic Policy Gradient

Input data





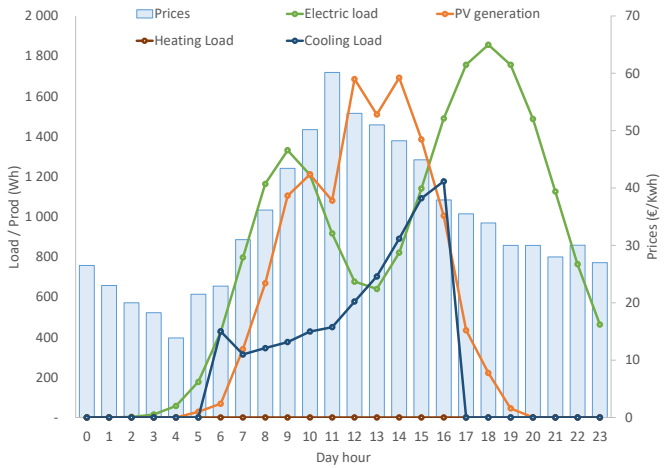


Figure: Example of historical data for a typical winter day/ summer day

A benchmark solution: MPC

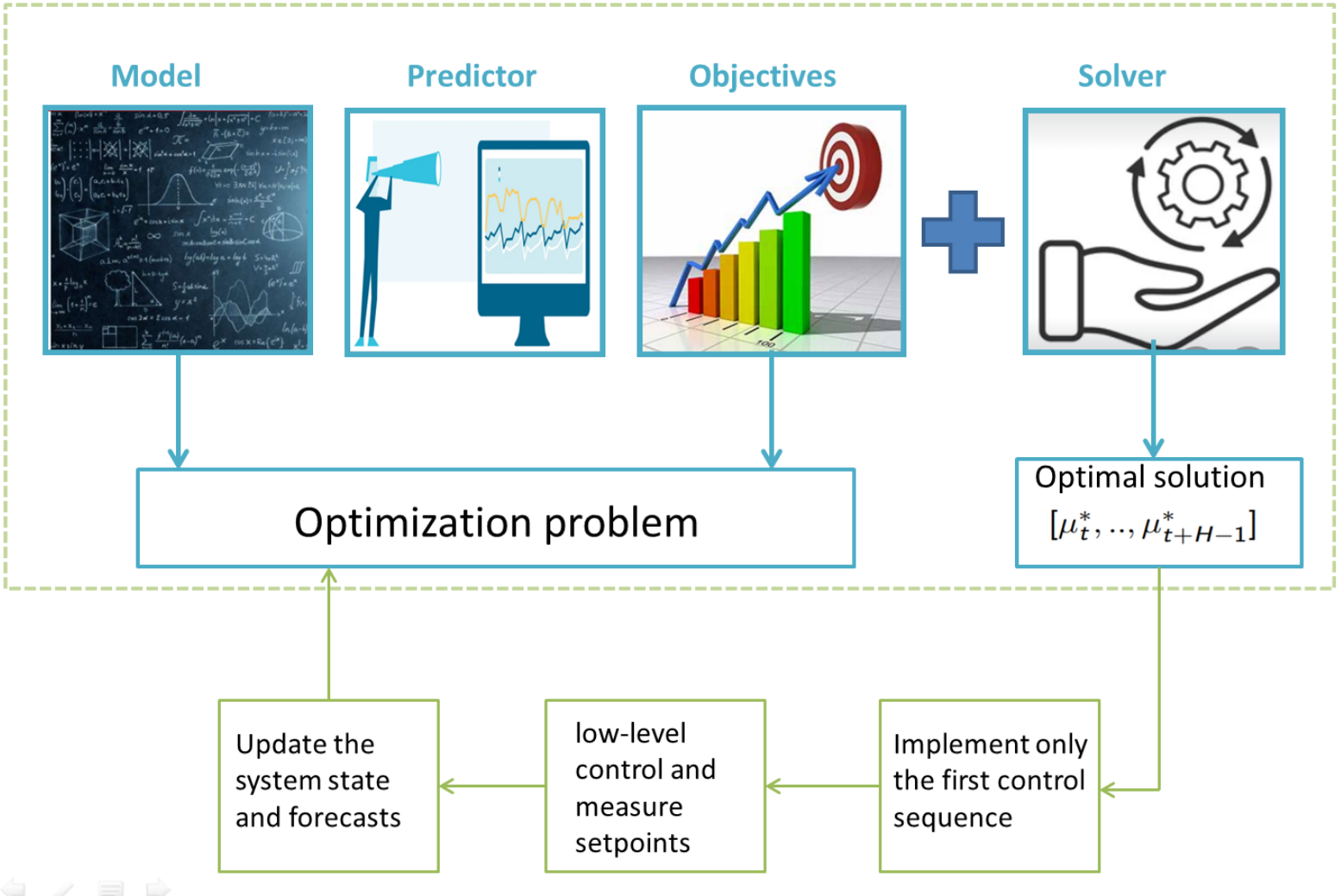


Figure: Model Predictive Control

Some results

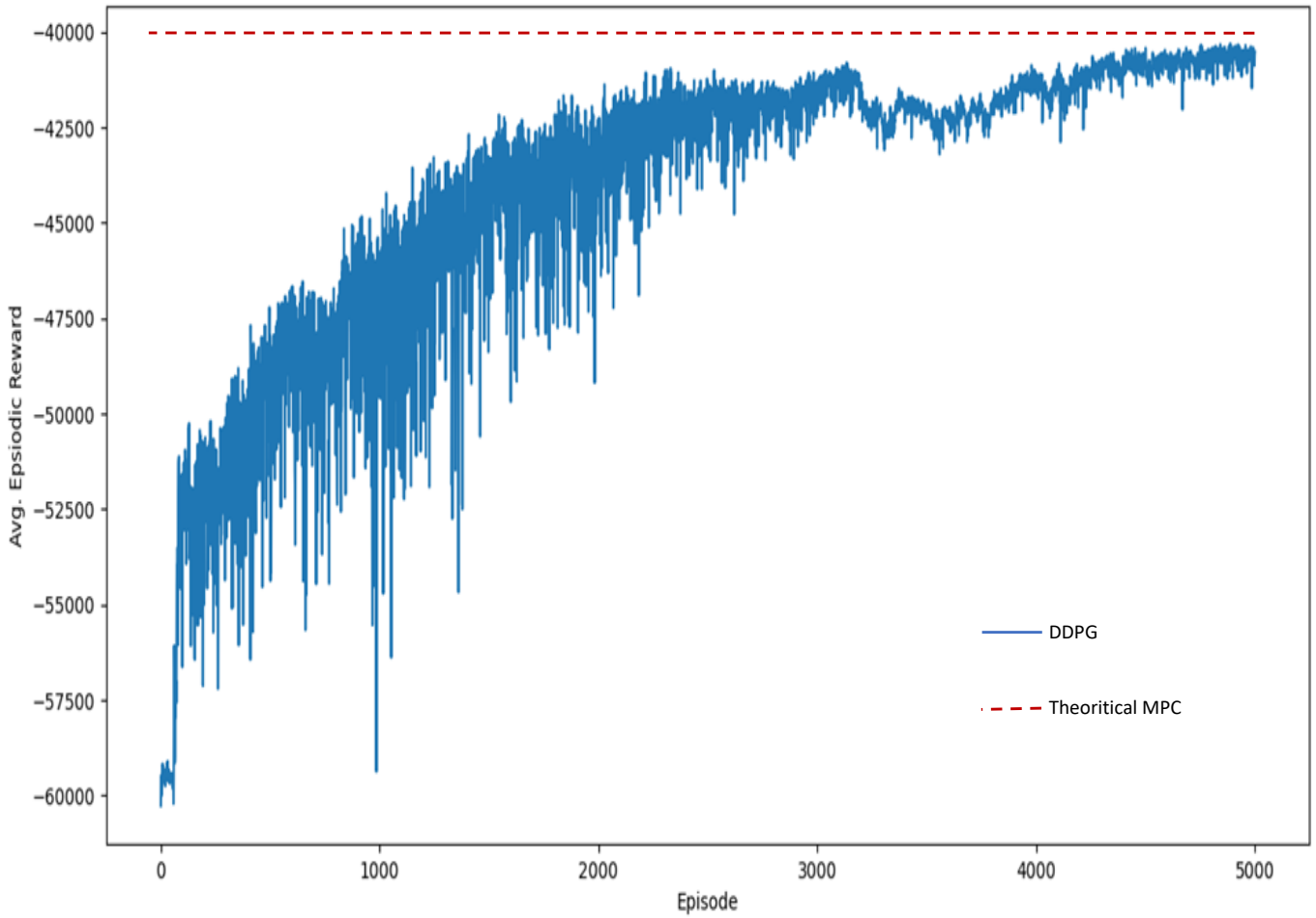


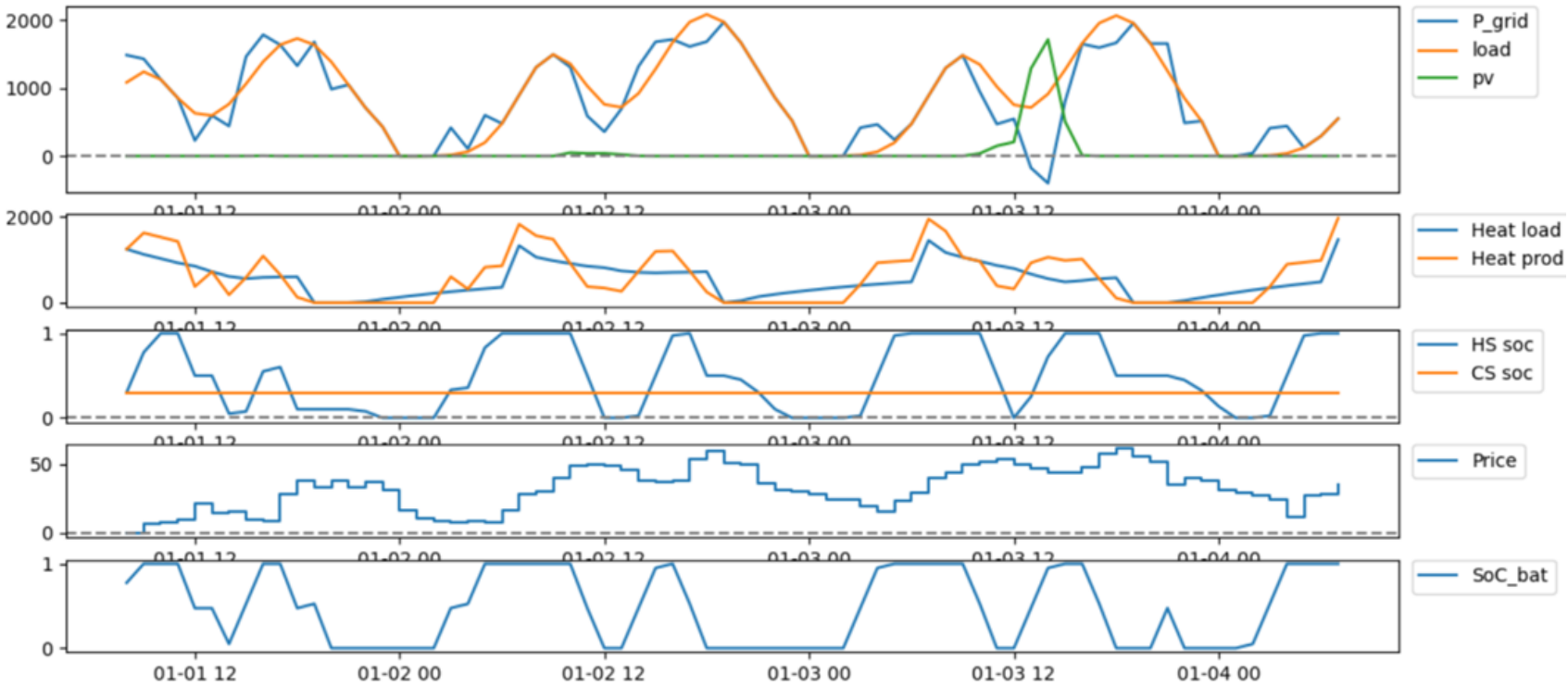
Figure: Learning curve for a 5000 episode training

Some results

HS soc: State of charge of the heating storage

CS soc: State of charge of the cooling storage

SoC_bat: State of charge of the battery



Summary and future work

- This work proposes a strategy for the optimal operation of a multi-energy Smart Grid
- It uses a DRL approach (Deep Deterministic Policy gradient algorithm)
- Future works include a further comparison of the performance the DRL approach with the benchmark solutions
- The model of the environment will be replaced with the digital twin, then with the district-level real-life Smart Grid

Thank you for your attention!